Fermilab

Directorate

TECHNICAL SCOPE OF WORK
FOR THE 2013 FERMILAB TEST BEAM FACILITY PROGRAM

T-1037

FLYSUB-Consortium Tracking and RICH Performance Evaluation

Aug 23, 2013

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INTRODUCTION

This is a technical scope of work (TSW) between the Fermi National Accelerator Laboratory (Fermilab) and the experimenters of FLYSUB-Consortium who have committed to participate in beam tests to be carried out during the 2013 – 2014 Fermilab Test Beam Facility program.

The TSW is intended primarily for the purpose of recording expectations for budget estimates and work allocations for Fermilab, the funding agencies and the participating institutions. It reflects an arrangement that currently is satisfactory to the parties; however, it is recognized and anticipated that changing circumstances of the evolving research program will necessitate revisions. The parties agree to modify this scope of work to reflect such required adjustments. Actual contractual obligations will be set forth in separate documents.

This TSW fulfills Article 1 (facilities and scope of work) of the User Agreements signed (or still to be signed) by an authorized representative of each institution collaborating on this experiment.

Description of Detector and Tests:

FLYSUB is a consortium consisting of BNL, Florida Tech, Stony Brook University (SBU), University of Virginia (UVa), and Yale University and is planning to assemble a set of detectors at FTBF which is targeted toward tracking and PID components of an EIC detector. The groups have been working together for about two years and have come up with a common beam-time usage instead of asking for separate test-beam campaigns, with the set-up described in what follows. The ultimate goal of this test-beam effort is to test and verify the performance of the individual components according to their expectation. The detectors are foreseen to share the same beam-line and will be arranged according to their need for particle impact.
The fundamental areas of investigations driving the need of a test-beam campaign are:

- Development of a mini-drift GEM detector for resolving the issue of losing resolution for inclined particle tracks and applying different frontend electronics
- Development of large area planar GEM detectors for endcap tracking
- Development of Cherenkov detectors in the forward direction, with particular emphasis on high momentum hadron ID and development of large area low cost VUV mirrors
- Development of alternative read-out structures for reducing the number of channel counts but conserving the resolution

These areas are split among the institutions and individual contributions are described in the following.

1.) BNL: Test of a mini-drift GEM detector which is made out of standard 10x10cm^2 GEM foils with increased drift gap (> 17 mm). The readout will be performed with SRS-DAQ. Gas to be used is mixed Ar-CO_2 (various mixtures), and pure CF_4. No special cooling required.

Main goal is to measure position and angular resolution. Desired angular range is 0° to 45°.

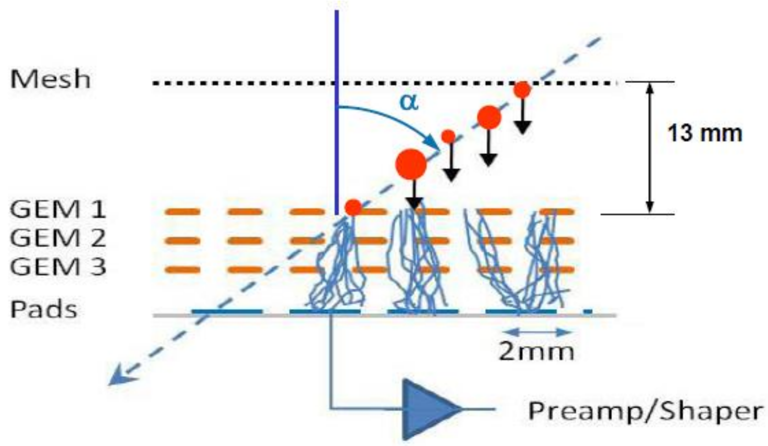


Figure 1 Illustration of mini-drift GEM detector with pad readout.

2.) Florida Tech+UVa: one (possibly two) chambers with 100 cm × (44 – 22) cm trapezoidal prototypes and radial strip readout (24 sectors with 12cm strip length) and one more chamber with zigzag strips would be inserted in the beam line.

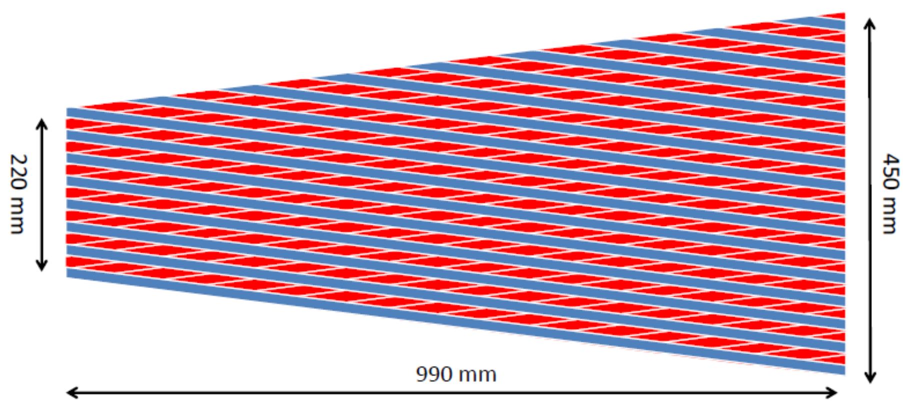


Figure 2 Radial strip readout for a trapezoidal GEM chamber.

Furthermore, a 50 x 50 cm^2 GEM prototype chamber and a 30 x 30 cm^2 self-stretched EIC GEM prototype with zigzag readout strips will be implemented. As a reference tracking system it is planned to provide one 10 × 10 cm^2 Micromegas detector, one or two 10 × 10 cm^2 Triple-GEM chambers, and one 30 × 30 cm^2 self-stretched Triple-GEM with Cartesian readout (COMPASS style).

The main goal of the studies is to investigate their spatial and timing resolutions for non-standard strip readout geometries (u-v, zigzag) under various conditions:

i. Without magnetic field
ii. Response under highest available rates
iii. Two-track resolutions
iv. With various gas mixtures of Ar/CO_2

3.) Stony Brook University: The aim of this test is to verify the performance of a Ring-Imaging-Cherenkov (RICH) detector based on Gas-Electron-Multiplier (GEM) detectors and CF_4 as the radiator/counting gas. This technology is foreseen to become part of the Particle Identification (PID) system of an EIC-detector.
The detector consists of a stainless steel tube which is closed at one end with a mirror and at the other end with the GEM-detector in the focal plane of that mirror. The readout plane for a quintuple-GEM detector can be interchanged between two-dimensional strip and single pads readout. The primary goal of the tests is to prove that the ring diameter obtained with both readout-plane structures will suffice particle discrimination up to high momenta.

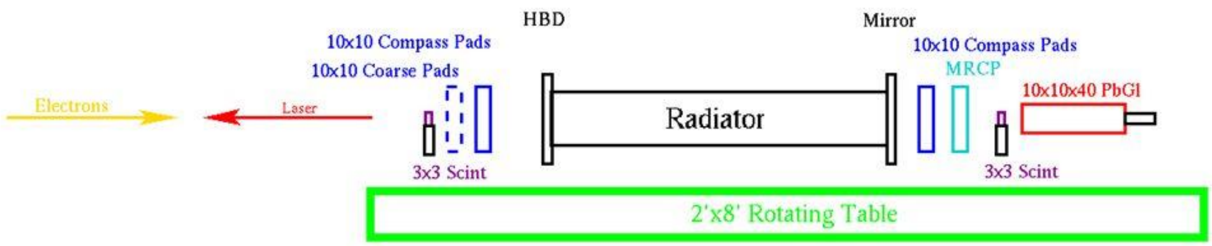


Figure 3: Drawing (not to scale) of the proposed setup for the test in beam of the RICH prototype.

4.) Yale University: Two sets of 4 chambers each, 10 x 10 cm^2 active area, ~1.2% RL each chamber. Each set of 4 chambers will take about 2 feet along the beam line. The readout structure of these detectors is based on a 3-coordinate single readout plane. The goal of the tests is to investigate charge sharing ratio and uniformity of the ratio and ultimately resolution.

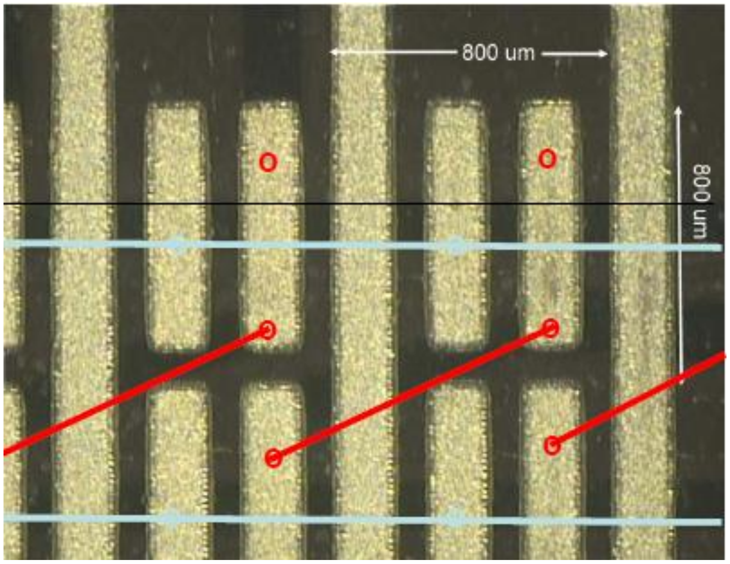


Figure 4: Three-dimensional single readout plane realized by interconnecting different lines of readout strips/pads.

I. PERSONNEL AND INSTITUTIONS:

Spokesperson: Klaus Dehmelt (Stony Brook University)

Fermilab liaison: Aria Soha

The group members at present are:

	Institution	Country	Collaborator	Rank/Position	Other Commitments
1.1	Brookhaven National Lab	USA	Bob Azmoun	Research Scientist	PHENIX
			Marie Blatnik	Undergraduate student	
			Robert Pak	Research Scientist	PHENIX
			Martin Purschke	Research Scientist	PHENIX
			Benedetto Di Ruzza	Research Scientist	STAR
			Craig Woody	Research Scientist	PHENIX
1.2	Florida Tech	USA	Vallary Bhopatkar	Graduate student	
			Marcus Hohlmann	Professor	CMS
			Jessie Twigger	Undergraduate student	
			Aiwu Zhang	Postdoc	
1.3	Stony Brook University	USA	Klaus Dehmelt	Research Scientist	PHENIX
			Abhay Deshpande	Professor	PHENIX
			Nils Feege	Postdoc	PHENIX
			Thomas Hemmick	Professor	PHENIX
1.4	University of Virginia	USA	Xinzhang Bai	Graduate student	
			Kondo Gnanvo	Research Scientist	SOLID
			Chao Gu	Graduate student	
			Nilanga Liyanage	Professor	SOLID
1.5	Yale University	USA	Richard Majka	Research Scientist	STAR
			Nikolai Smirnov	Research Scientist	STAR/ATLAS

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS:

2.1 LOCATION

2.1.1 The various detectors will be placed in MT6.2 along the beam-line and one detector (mini-drift GEM detector) will be placed in MT6.1 within the CAPTAN Si-telescope (see Appendix I)

2.1.2 Additional space needed:

- Control room for various PCs/monitors and table space
- Electronics Room: four racks
- Storage room: to store shipping boxes for the items
- Meetings in conference room on a daily basis

2.1.3 Access to laminar flow bench with HEPA filters would be useful in case any of the GEM detectors need servicing.

2.2 BEAM

2.2.1 BEAM TYPES AND INTENSITIES

Particles: electrons
Energy of beam: 10 GeV
Intensity: Single particles (if possible) to few kHz
Beam spot size: as small as possible

Particles: pions
Energy of beam: > 4 GeV (> 20 GeV)
Intensity: single particles (if possible); variations 1k – 100k particles/ 4 sec spill
Beam spot size: as small as possible; about 1 cm^2

Particles: Kaons
Energy of beam: > 13 GeV
Intensity: single particles (if possible) to few kHz
Beam spot size: as small as possible

Particles: protons
Energy of beam: > 27 GeV
Intensity: single particles (if possible) to few kHz
Beam spot size: as small as possible

The experimenters have set up a beam-run-table which includes a detailed plan about running with different particle species at different momenta. See section 2.3.3 for details.

2.2.2 Beam Sharing

Because this experiment consists of multiple detectors in multiple locations beam-sharing with other experiments is unlikely to work out due to physical limitations.

2.2.3 Running Time

The first day of requested time will be used for Mechanical Setup, cable and utility hook-up, start of gas flow, and begin electronics check out. Since the test beam will likely have a decent beam trigger, the experiment's part is mainly to set up and incorporate busy signals. The second day will be used to finish electronics checkout, and high voltage check. The third day will be used to obtain ORC and start beam run. In the first week frequent access might be needed for debugging the set-ups. Change and fine-tuning of control parameters that cannot be performed remotely.

Run-time is expected to be 24 hours/day. A beam schedule is shown in Table 2, in section 2.3.3.

See section 2.4 for total run time and long-term schedule.

2.3 Experimental Conditions

2.3.1 Area Infrastructure

All detectors are gaseous detectors and will be read out by APV25-SRS electronics. The detector's dimensions are listed in Table 1.

Table 1 Dimensions and weights for the various detectors used in the set-up.

Item	Dimension h×w×d (cm×cm×cm)	Weight (kg)
12 GEM/MM tracker	10×10×4 each	5 each
2 GEM tracker	30×30×4	7
1 GEM tracker	50×50×4	8
Two large, trapezoidal GEM tracker	100×[40-22]×4 each	10
RICH detector (on table)	100×65×245	150

All detectors except the RICH-detector need mounting structures that can be adjusted such that the detectors can be moved into the beam. The RICH-detector will be coming mounted on a supporting table that can be adjusted such that the RICH detector can be aligned with the beam.

Each detector will be read out with APV25-SRS-electronics. For that each crate needs a GB-Ethernet connection to the control room.

The experiment requests precise tracking detectors (e.g. Si-strip telescope) and trigger scintillators, as well as Cherenkov-detectors for particle identification, to be provided by FTBF.

The experiment will use Patch-panels (BNC, LEMO) in the counting house leading to the experimental area.

So long as the experimenters can easily access the apparatus in the enclosure in the case of a power outage there is no need for UPSs.

The detectors will need to be supplied with gas. Various gas mixtures would be needed. The RICH detector will need CF_4. Other mixtures are basically Ar-CO_2 mixtures with different ratios. The CF_4 gas would be required to be ordered by the experiment to be delivered to Fermilab or ordered through Fermilab. FTBF has a gas room outside the main hall. Bottles and regulators are there with copper lines running to panels within the enclosure. The experimenters would set gas manifolds (19" rack mount panels) near the detectors to be connected to the patch panels.

The RICH detector needs a rack placed close to the set-up. The gas system is a pressure regulated closed loop system and long gas lines would pose a risk in the regulating mechanism.

The experiment will need an opportunity to survey the detector's positions with respect to each other and to the beam line, using the laser alignment system provided by FTBF

2.3.2 Electronics Needs

The groups will provide electronics for each individual detector, and diagrams will be provided when requested. Cables might be needed for extending the set-up.

No PREP electronics are requested.

2.3.3 Description of Tests

The detectors will be prepared by the various groups at their home institutes such that the operational status is defined. Once the detectors are operational the parts which are permanently attached to non-movable parts will be disconnected and shipped to Fermilab. This will reduce set-up time at the test-facility. There the detectors will be set up and connected and the systems will be checked for operation and the readout performance will be evaluated during the first week of the 3-week beam request. Once these issues are set the experiment can start with exposing the detectors to the beam.

It is planned to start the tests with conditions that all detector tests will have in common. A general plan can be found in Table 2.

Table 2: General run plan. The run plan starts with the first day of requesting particles traversing the detectors.

Day	Particle species	Energy	Particle count[1]	Spot size (cm^2)
1-3 (Setup, commissioning, and OCR)	Pion	> 20 GeV	few kHz	< 1
4-7	Protons	120 GeV	few kHz	variable
8-10	Pion	> 4 GeV incrementing in 1.) 2 GeV steps up to 10 GeV (4 sets) 2.) 5 GeV steps up to 35 GeV (5 sets)	single to few kHz	< 1
11-13	Kaon	> 16 GeV incrementing in 1.) 2 GeV steps up to 20 GeV (3 sets) 2.) 5 GeV steps up to 45 GeV (5 sets)	single to few kHz	< 1
14-16	Proton	> 29 GeV incrementing in 1.) 2 GeV steps up to 35 GeV (3 sets) 2.) 5 GeV steps up to 45 GeV (2 sets)	single to few kHz	< 1
17-18	Identified electrons	1 GeV < E < 10 GeV	1 kHz	1
19	Pions	30 GeV	100 kHz	As small as possible
20-21	TBD			

Detectors will be staying in the beam-line all time, except when experiencing issues with them. Access to the area would be requested when necessary, though it is expected to control the detectors remotely.

[1] In units of particles per 4 sec spill.

2.4 SCHEDULE

The experiment requests a total of two weeks beam-time, plus an additional three to four days of set-up and debugging of which one or two might be with beam particles. The experiment would like to request the first three weeks in October 2013 for the test-beam campaign.

III. Responsibilities by Institution – Non Fermilab

3.1 BNL and Yale University:

will contribute a prototype of a mini-drift TPC (small GEM detector) based on SRS-electronics and two stations of each four small GEM trackers with SRS-readout.

3.2 Florida Tech and University of Virginia:

will contribute two large, trapezoidal GEM trackers, one large sized squared GEM tracker, two medium sized squared GEM tracker, and three small sized reference trackers. All detectors are read out based on SRS-electronics.

3.3 Stony Brook University:

will contribute a RICH detector based on GEMs and SRS-readout. Will also provide a set of two PbGl calorimeter blocks and NIM readout electronics (if needed).

IV. RESPONSIBILITIES BY INSTITUTION – FERMILAB

4.1 FERMILAB ACCELERATOR DIVISION:

4.1.1 Use of MTest beamline as outlined in Section II.
4.1.2 Maintenance of all existing standard beam line elements (SWICs, loss monitors, etc) instrumentation, controls, clock distribution, and power supplies.
4.1.3 Scalers and beam counter readouts will be made available via ACNET in the MTest control room.
4.1.4 Reasonable access to the equipment in the MTest beamline.
4.1.5 Connection to beams console and remote logging (ACNET) should be made available.
4.1.6 The test beam energy and beam line elements will be under the control of the AD Operations Department Main Control Room (MCR). [1.5 person-weeks]
4.1.7 Position and focus of the beam on the experimental devices under test will be under control of MCR. Control of secondary devices that provide these functions may be delegated to the experimenters as long as it does not violate the Shielding Assessment or provide potential for significant equipment damage.
4.1.8 The integrated effect of running this and other SY120 beams will not reduce the neutrino flux by more than an amount set by the office of Program Planning, with the details of scheduling to be worked out between the experimenters and the Office of Program Planning.

4.2 FERMILAB PARTICLE PHYSICS DIVISION:

4.2.1 The test-beam efforts in this TSW will make use of the Fermilab Test Beam Facility. Requirements for the beam and user facilities are given in Section II. The Fermilab Particle Physics Division will be responsible for coordinating overall activities in the MTest beam-line, including use of the user beam-line controls, readout of the beam-line detectors, and FTBF computers. [3.0 person weeks]
4.2.2 Set up and maintenance of Si tracking system. [1.0 person weeks]
4.2.3 Setup and maintenance of trigger scintillators.
4.2.4 Conduct a NEPA review of the experiment.
4.2.5 Provide day-to-day ESH&Q support/oversight/review of work and documents as necessary.
4.2.6 Provide safety training as necessary, with assistance from the ESH&Q Section.
4.2.7 Update/create ITNA's for users on the experiment.
4.2.8 Initiate the ESH&Q Operational Readiness Clearance Review and any other required safety reviews. [0.2 person-weeks]

4.3 FERMILAB SCIENTIFIC COMPUTING DIVISION

4.3.1 Internet access should be continuously available in the MTest control room.
4.3.2 GB Ethernet connection between beam enclosure and control room.
4.3.3 See Appendix II for summary of PREP equipment pool needs.

4.4 FERMILAB ESH&Q SECTION

4.4.1 Assistance with safety reviews.

4.4.2 Provide safety training, with assistance from PPD, as necessary for experimenters. [0.2 person weeks]

V. Summary of Costs

Source of Funds [$K]	Materials & Services	Labor (person-weeks)
Particle Physics Division	0.0	2.2
Accelerator Division	0	1.5
Scientific Computing Division	0	0
ESH&Q Section	0	0.2
Totals Fermilab	$0.0K	3.9
Totals Non-Fermilab	[specify from Section III]	[specify]

VI. General Considerations

6.1 The responsibilities of the Spokesperson and the procedures to be followed by experimenters are found in the Fermilab publication "Procedures for Researchers": (http://www.fnal.gov/directorate/PFX/PFX.pdf). The Spokesperson agrees to those responsibilities and to ensure that the experimenters all follow the described procedures.

6.2 To carry out the experiment a number of Environmental, Safety and Health (ESH&Q) reviews are necessary. This includes creating an Operational Readiness Clearance document in conjunction with the standing Particle Physics Division committee. The Spokesperson will follow those procedures in a timely manner, as well as any other requirements put forth by the Division's Safety Officer.

6.3 The Spokesperson will ensure at least one person is present at the Fermilab Test Beam Facility whenever beam is delivered and that this person is knowledgeable about the experiment's hazards.

6.4 All regulations concerning radioactive sources will be followed. No radioactive sources will be carried onto the site or moved without the approval of the Fermilab ESH&Q section.

6.5 All items in the Fermilab Policy on Computing will be followed by the experimenters. (http://computing.fnal.gov/cd/policy/cpolicy.pdf).

6.6 The Spokesperson will undertake to ensure that no PREP or computing equipment be transferred from the experiment to another use except with the approval of and through the mechanism provided by the Scientific Computing Division management. The Spokesperson also undertakes to ensure no modifications of PREP equipment take place without the knowledge and written consent of the Computing Sector management.

6.7 The experimenters will be responsible for maintaining both the electronics and the computing hardware supplied by them for the experiment. Fermilab will be responsible for repair and maintenance of the Fermilab-supplied electronics. Any items for which the experiment requests that Fermilab performs maintenance and repair should appear explicitly in this agreement.

At the completion of the experiment:

6.8 The Spokesperson is responsible for the return of all PREP equipment, computing equipment and non-PREP data acquisition electronics. If the return is not completed after a period of one year after the end of running the Spokesperson will be required to furnish, in writing, an explanation for any non-return.

6.9 The experimenters agree to remove their experimental equipment as the Laboratory requests them to. They agree to remove it expeditiously and in compliance with all ESH&Q requirements, including those related to transportation. All the expenses and personnel for the removal will be borne by the experimenters unless removal requires facilities and personnel not able to be supplied by them, such a rigging, crane operation, etc.

6.10 The experimenters will assist Fermilab with the disposition of any articles left in the offices they occupied.

6.11 An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters' Meeting.

SIGNATURES:

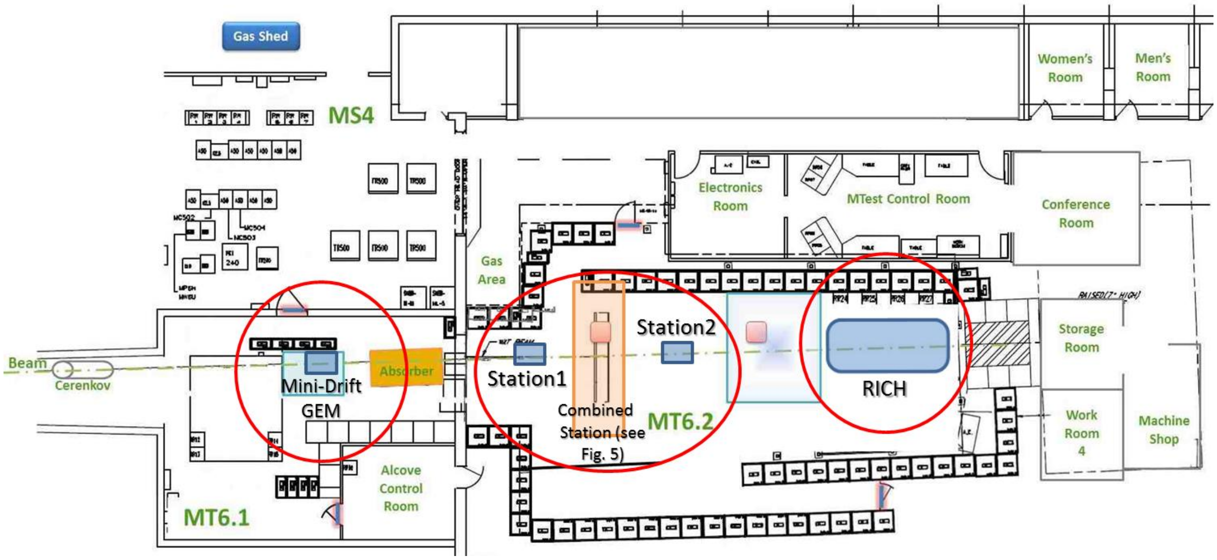
____ / / 2013

Klaus Dehmelt, Experiment Spokesperson

APPENDIX I: MT6 AREA LAYOUT

MT6.1/2 Layout with all detectors along the beam-line (detectors are not to scale).

MTEST AREAS



Station 1	4 GEM tracker (10x10cm^2 each)
Station 2	4 GEM tracker (10x10cm^2 each)
Medium GEM	1 GEM tracker 30x30cm^2
Trapezoidal GEM	Two large, trapezoidal GEM tracker (100cmx[40-22]cm) (UVa/FIT CMS GEM)
Ref tracker	1 GEM tracker (10x10cm^2), 2 GEM tracker (10x10cm^2 each), 1 MM tracker 10x10cm^2
Large GEM	One GEM tracker 50x50cm^2
RICH	RICH detector on table 4'x8'

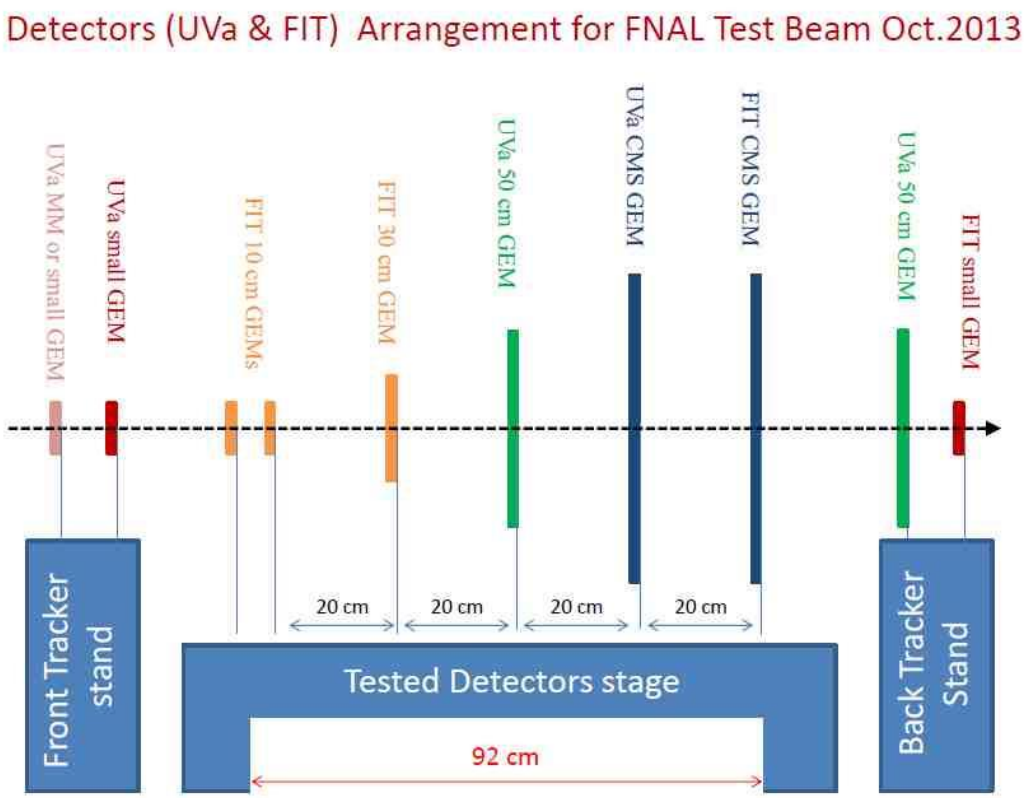


Figure 5 Combined Station

APPENDIX II: - HAZARD IDENTIFICATION CHECKLIST

Items for which there is anticipated need *should be* checked. See next page for detailed descriptions of categories.

Flammable Gases or Liquids		**Other Gas Emissions**		**Hazardous Chemicals**		**Other Hazardous /Toxic Materials**
Type:		Type:	CF_4 , Ar/CO_2		Cyanide plating materials	List hazardous/toxic materials planned for use in a beam line or an experimental enclosure:
Flow rate:		Flow rate:	10cc/min up to 400cc/min Ar/CO_2 500cc/min CF_4		Hydrofluoric Acid	
Capacity:		Capacity:	CF_4:40L/1200psi Ar-CO_2:40L/2300psi		Methane	CF_4 gas
Radioactive Sources		**Target Materials**			photographic developers	
	Permanent Installation		Beryllium (Be)		PolyChlorinatedBiphenyls	
X	Temporary Use		Lithium (Li)		Scintillation Oil	
Type:	Cd-109, Sr-90, Fe-55 (2x)		Mercury (Hg)		TEA	
Strength:			Lead (Pb)		TMAE	
Lasers			Tungsten (W)		Other: Activated Water?	
	Permanent installation		Uranium (U)			
	Temporary installation		Other:	**Nuclear Materials**		
	Calibration	**Electrical Equipment**		Name:		
	Alignment		Cryo/Electrical devices	Weight:		
Type:			Capacitor Banks	**Mechanical Structures**		
Wattage:			High Voltage (50V)		Lifting Devices	
MFR Class:			Exposed Equipment over 50 V		Motion Controllers	
		X	Non-commercial/Non-PREP	X	Scaffolding/ Elevated Platforms	
			Modified Commercial/PREP		Other:	
Vacuum Vessels		**Pressure Vessels**		**Cryogenics**		
Inside Diameter:		Inside Diameter:			Beam line magnets	
Operating Pressure:		Operating Pressure:			Analysis magnets	
Window Material:		Window Material:	Gas bottle		Target	
Window Thickness:		Window Thickness:			Bubble chamber	

Other Gas Emission

Greenhouse Gasses (Need to be tracked and reported to DOE)

- ❑ Carbon Dioxide, including CO_2 mixes such as Ar/CO_2
- ❑ Methane (Tetrafluormethane)
- ❑ Nitrous Oxide
- ❑ Sulfur Hexafluoride
- ❑ Hydro fluorocarbons
- ❑ Per fluorocarbons
- ❑ Nitrogen Trifluoride

Nuclear Materials

Reportable Elements and Isotopes / Weight Units / Rounding

Name of Material	MT Code	Reporting Weight Unit Report to Nearest Whole Unit	Element Weight	Isotope Weight	Isotope Weight %
Depleted Uranium	10	Whole Kg	Total U	U-235	U-235
Enriched Uranium	20	Whole Gm	Total U	U-235	U-235
Plutonium-242[1]	40	Whole Gm	Total Pu	Pu-242	Pu-242
Americium-241[2]	44	Whole Gm	Total Am	Am-241	–
Americium-243[2]	45	Whole Gm	Total Am	Am-243	–
Curium	46	Whole Gm	Total Cm	Cm-246	–
Californium	48	Whole Microgram	–	Cf-252	–
Plutonium	50	Whole Gm	Total Pu	Pu-239+Pu-241	Pu-240
Enriched Lithium	60	Whole Kg	Total Li	Li-6	Li-6
Uranium-233	70	Whole Gm	Total U	U-233	U-232 (ppm)
Normal Uranium	81	Whole Kg	Total U	–	–
Neptunium-237	82	Whole Gm	Total Np	–	–
Plutonium-238[3]	83	Gm to tenth	Total Pu	Pu-238	Pu-238
Deuterium[4]	86	Kg to tenth	D_2O	D_2	
Tritium[5]	87	Gm to hundredth	Total H-3	–	–
Thorium	88	Whole Kg	Total Th	–	–
Uranium in Cascades[6]	89	Whole Gm	Total U	U-235	U-235

[1] Report as Pu-242 if the contained Pu-242 is 20 percent or greater of total plutonium by weight; otherwise, report as Pu 239-241.

[2] Americium and Neptunium-237 contained in plutonium as part of the natural in-growth process are not required to be accounted for or reported until separated from the plutonium.

[3] Report as Pu-238 if the contained Pu-238 is 10 percent or greater of total plutonium by weight; otherwise, report as plutonium Pu 239-241.

[4] For deuterium in the form of heavy water, both the element and isotope weight fields should be used; otherwise, report isotope weight only.

[5] Tritium contained in water (H2O or D2O) used as a moderator in a nuclear reactor is not an accountable material.

[6] Uranium in cascades is treated as enriched uranium and should be reported as material type 89.

The following people have read this TSW:

____ / / 2013
Michael Lindgren, Particle Physics Division, Fermilab

____ / / 2013
Roger Dixon, Accelerator Division, Fermilab

____ / / 2013
Robert Roser, Scientific Computing Division, Fermilab

____ / / 2013
Martha Michels, ESH&Q Section, Fermilab

____ / /2013
Greg Bock, Associate Director for Research, Fermilab

____ / /2013
Stuart Henderson, Associate Director for Accelerators, Fermilab